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HIGH-SPEED CONTAINER DELIVERY SYSTEM (HSCDS): BEST TECHNICAL APPROACH

by
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13. ABSTRACT *(Maximum 200 words)*
In May 1992, Natick conducted a Best Technical Approach (BTA) for the High Speed Container Delivery System (HSCDS) to be incorporated into the Cost and Operational Effectiveness Analysis (COEA) being prepared by the U.S. Army Quartermaster School. The BTA was prepared in-house; whereas, the COEA was performed by a contractor (American Power Jet). The first objective of the BTA is to summarize the most plausible technical approaches that were studied in the Trade Off Determination (TOD). Cost data is provided for these technical approaches. Next, the material developers' recommended approach is described and justified. Finally, any environmental and MANPRINT concerns are identified for the recommended approach. To follow in the same format as the TOD, the BTA discusses the three major subsystems of the HSCDS. Cost data and performance descriptions are provided on the container subsystem, main recovery subsystem, and the extraction/ejection subsystem.

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PREFACE AND ACKNOWLEDGEMENTS

This report is the third deliverable of the Concept Formulation Package (CFP) described in Army Regulation 71-9, and is based on the results of the Trade Off Determination (TOD) and the Trade Off Analysis (TOA) documents. This Best Technical Approach (BTA) reviews the most promising alternatives for a new aerial delivery container system for the United States Army, and selects the best approach based on performance, operational suitability, estimated cost, and schedule. The new system must provide the capability to airdrop supply containers from U.S. Air Force cargo aircraft flying at 300 foot altitudes and 250 knot airspeeds.

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SUMMARY

The High-Speed Container Delivery System (HSCDS) airdrop development program addresses the U.S. Army's need for a system to airdrop containerized equipment and supplies (up to 2,200 pounds per container) from U.S. Air Force cargo aircraft flying at high airspeeds (up to 250 knots) and low altitudes (300 feet above ground level or lower).

The first objective of this BTA was to summarize the most credible technical approaches that were studied in the TOD, and to provide cost data for these. Next, the materiel developers recommended best technical approach was described, with rationale for the selection of that approach.

The system was broken down into three critical components or subsystems; the **container subsystem**, the **main recovery subsystem**, and the **extraction/ejection subsystem**. The most promising technical approaches for each were reviewed one subsystem at a time. Three separate recommendations were made, one for each subsystem. Additionally, a recommendation was made concerning the maintaining one system for all airspeeds, versus maintaining two systems, one for low speeds (130-150 knots) and one for high-speeds (150-250 knots).

Container Subsystem

Both rigid and cargo net containers have certain advantages and disadvantages. However, before one type can be chosen over the other, it was recommended that breadboard prototypes of both containers be designed, constructed, and tested. R&D costs and annual production, fielding, facilities and sustainment costs to support training requirements were estimated for the most promising container candidates. The cargo net design has significant advantages over the rigid concept in terms of container weight, storability, maintenance and unit cost. Therefore, if the cargo net container fares well during the technical demonstration, especially in the areas of in-flight restraint and load shift during parachute extraction, the improved cargo net type will be recommended for inclusion in the Engineering and Manufacturing Development program.

Main Recovery Subsystem

The recommended best approach is that a single mode, intermediate descent velocity system be developed and demonstrated for HSCDS. Also, it is technically best to design the system with a more consistent descent rate than the current system. It was recommended that the descent rate be constrained to a narrower range (e.g., between 30 and 40 fps for all container weights). R&D costs and annual production, fielding, facilities and sustainment costs to support training requirements were estimated for the most promising main recovery subsystem candidates. Both single canopies and clusters of smaller canopies were considered.

A single 45 foot diameter flat circular solid construction parachute was recommended as the best approach from a performance and cost standpoint. The use of variable reefing in the main chute should be incorporated to maintain a more consistent descent rate, unless complexity and cost factors render it unattractive. It was estimated that the new 45 foot canopy with variable reefing will cost significantly less than the standard 64 foot G-12E parachute ($1,070 vs. $1,750). Utilizing this new main parachute will greatly reduce the unit cost for the system, as well as, annual training and support costs. Cost savings realized for the main chute can be applied to the new container and extraction subsystems.

Extraction/Ejection Subsystem

The current method of extraction (gravity extraction at level flight) cannot be achieved efficiently at airspeeds greater than 150 Knots Indicated Airspeed (KIAS). In the TOD, four alternative methods were studied. The aerodynamic (parachute) method has the most potential for success. Specifically, the simultaneous parachute extraction method was identified as the best approach. This type of extraction subsystem will consist of a drogue/tow parachute, extraction parachute(s), and an extraction bridle/pusher assembly. It was recommended that the tow plate assembly be used for all airdrops at high-speed. R&D costs and annual production, fielding, facilities and sustainment costs to support training requirements were estimated for this extraction subsystem and its components. It was estimated that 8,000 containers will be airdropped per year, during a total of 1,000 passes over the drop zone. Therefore, it was estimated that one extraction subsystem will be required for every eight containers/main recovery parachutes. Consequently, it was estimated that the simultaneous parachute extraction subsystem will comprise only 1 to 2 percent of the total unit cost of the system.

Number of Systems

It was recommended that a single high/low speed system be developed in lieu of one system for low speeds and one system for high-speeds. The new main parachute should perform adequately over the full range of airspeeds (130 to 250 KIAS). Simultaneous parachute extraction should be used at all airspeeds, to dramatically improve point of impact accuracy and reduced dispersion, leading to smaller drop zone requirements. Production, logistical, and other costs will be less for maintaining a single system. The establishment of a single system will also allow for operational flexibility in the event that airspeeds need to be changed during a mission.

A primary objective of HSCDS is to improve aircraft survivability during container airdrop missions. This BTA suggests that a new system could be developed to accomplish this objective, while maintaining a lower life cycle cost than the current container delivery system. Even if the system were never employed at high-speed, and the system was developed and fielded for low speed use only, it would be cost effective. Since the HSCDS will provide improvements for all airspeeds (e.g., better accuracy, improved rigging/derigging, and upgraded load survivability) continued development of HSCDS should be considered a high priority, regardless of the systems ultimate employment scenario.

HIGH-SPEED CONTAINER DELIVERY SYSTEM (HSCDS): BEST TECHNICAL APPROACH

1.0. INTRODUCTION

The High-Speed Container Delivery System (HSCDS) airdrop development program addresses the U.S. Army's need for a system to airdrop containerized equipment and supplies (up to 2,200 pounds per container) from U.S. Air Force cargo aircraft flying at high airspeeds (up to 250 KIAS) and low altitudes (300 feet AGL or lower). This need is consistent with a Military Airlift Command (MAC)/Training and Doctrine Command (TRADOC) Memorandum of Agreement (MOA) which states that future airdrop systems for personnel, vehicles, equipment and supplies will be deployed at lower altitudes and higher airspeeds. In addition, the United States Special Operations Command (USSOCOM) has expressed interest in the low and fast resupply capability for Special Operations use.

The HSCDS program is the second phase of the two-phase Enhanced Container Delivery System (ECDS) program. The first phase (referred to as the interim system) was conducted to reduce the minimum drop altitude from 600 feet to 300 feet AGL at current airspeeds. The interim program maximized the use of existing materials to satisfy the requirements. The main recovery parachute was changed from the G-12D to the G-12E, which permitted the airdrop altitude to be lowered to 300 feet AGL. The interim ECDS was adopted and authorized for use in December 1989. The high-speed phase of the program, initiated in January 1990, is aimed at satisfying the 250 KIAS requirement. The increase in delivery airspeed to 250 KIAS introduces significant technical challenges that must be met.

This document presents the materiel developer's best technical approach for the HSCDS program, which will also be proposed for entry into the Demonstration and Validation Phase of the Acquisition Process. This Best Technical Approach (BTA) incorporates the results of the Trade Off Determination (TOD) and the Trade Off Analysis (TOA) which were prepared by and coordinated between the Material Developer and Combat Developer.

The first objective of this report is to summarize the most credible technical approaches that were studied in the TOD. Next, the materiel developer's recommended best technical approach will be described, with rationale for the selection of that approach. Detailed cost data will be presented for the current system and for the recommended best alternatives. Finally, any environmental and MANPRINT concerns will be identified for the best approach.

As mentioned in the TOD, the HSCDS has been logically broken down into three critical components or subsystems; the **container subsystem**, the **main recovery subsystem**, and the **extraction/ejection subsystem**. The most promising technical approaches for each will be presented one subsystem at a time. Three separate recommendations will be made, one for each subsystem. Additionally, a recommendation will be made concerning maintaining one system for all airspeeds, versus maintaining two systems, one for low speeds (130-150 KIAS) and one for high-speeds (150-250 KIAS).

2.0. REVIEW OF MOST PROMISING ALTERNATIVES

2.1. Container Subsystem

2.1.1. Improved Cargo Net

This approach leverages on the basic concept of the currently used, A-22 container. However, considering the fact that the A-22 was designed in the early 1950's, this approach would take a fresh look at every aspect of this type of container; the cargo cover, the webbing net/sling assembly, the suspension webs, the skidboard and the load/skidboard restraint method. It has been assumed that paperboard honeycomb will be used for impact mitigation. However, the materiel developer is aware of a thermoplastic urethane honeycomb sheet material with characteristics similar to paper honeycomb. This material will cost more per sheet than paper honeycomb. However, it has memory and will, therefore, be reusable. Thermoplastic urethane sheets will be evaluated during the test program as a possible replacement for the paper honeycomb. Heavy duty ratchet buckles will be integrated into the cargo net webbing to improve the container's ability to resist load shift relative to itself and the honeycomb beneath the net. State-of-the-art materials handling and cargo restraint equipment will be used and will provide for noncomplex and quick rigging/derigging. A rigid type skid with tiedown provisions will replace the plywood skid. Use of standard military webbing and hardware will be maximized, except in those cases where doing so degrades container performance or is not cost effective. The cargo net would be capable of being doubled for items longer than 48 inches.

2.1.2. Rigid Container

The cargo-carrying area for this approach will be a rigid walled container. The material construction could be double wall extruded aluminum, composite, high-strength polymer, or some other material that meets the performance requirements. The container will have collapsible or separable walls for storage and to facilitate loading the container. A new skid with tiedown provisions will be connected to the container with webbing straps that have ratchet buckles or a unitized container with honeycomb inside could be introduced that would eliminate the need for a skid.

2.1.3. Container Base Dimensions

The A-22 container has a cargo-carrying area of 48 inches wide, 53 inches long and 66 inches high. However, with the introduction of the CVRS the length of the A-22 skid was reduced to 48 inches. Even though the A-22 bag has a base of 53 inches, it is not normally rigged longer than 48 inches. The maximum overall height of the A-22 rigged on honeycomb and with the parachute attached on top of the load is 83 inches. The A-22 can be doubled (48 by 96 by 66 inches) to accommodate larger equipment, such as AHKIO Sleds (88 inches long), snowmobiles (104 inches long), and bulk plywood or lumber resupply loads (usually 96 inches long).

The width of the container skid is governed by the aircraft rail systems. For CDS operations on board the C-130, MC-130 and C-141, the airdrop side rails and the Centerline Vertical Restraint System (CVRS) are utilized to create two rows, 48 inches wide each. For the C-17 aircraft, the airdrop side rails and the logistics rails are both used in lieu of the CVRS. Therefore, the skid width will be 48 inches. It is important to note that if the 48 inch dimension is too short, there is a possibility that the skid would not engage both the aircraft rail and the center rail. This is critical since in that case there would be no vertical restraint on the container. If the base width is too wide then the container will either not fit into the aircraft or it will jam upon loading or exit. Using the A-22 system, the plywood skid is cut in the field by hand. There exists a great risk right now that the plywood skid will be out of tolerance, which will invite these problems to occur. For any new skid design, the 48 inch dimension and its associated tolerance must be held firm to alleviate this problem.

Two different lengths for the container skid were studied in the TOD. The first is to maintain the current skid length of 48 inches, and the second is to increase the length to 60 inches. The increase to 60 inches was driven by the desire to accommodate ammunition pallets in the new container without breaking them down. The 48 inch long container would have a maximum rigged weight of 2,328 pounds, while the 60 inch long design would have a maximum rigged weight of 2,910 pounds. These weight restrictions are based on the Centerline Vertical Restraint System (CVRS) structural limitations. The capability to link two 48 inch long containers together will provide adequate volume to fit larger and heavier cargo (e.g., ammunition pallets). Double size containers should be designed to carry double the weight of a single container, unlike the current double A-22.

Ammunition pallets, rigged without being broken down, can not be delivered with the HSCDS until they have been certified for airdrop. Currently, the ammunition is broken down and packaged for airdrop to promote survivability of the rounds or missiles. The orientation of the rounds/missiles in the ammunition pallet, in general, is different than their orientation when packaged in an A-22 for airdrop. The cost for certification of one ammunition pallet for airdrop will exceed $100,000. The process is also very time consuming, since obtaining rounds/missiles and good fragility data is many times difficult. Therefore, since the driver to go to a 60 inch (or longer) container is so that ammunition pallets can be airdropped, then the associated certification costs and program delays must be considered. The additional cost would exceed $3,000,000 and the time required to certify the pallets would be at least 3 years. The certification effort could be conducted separate from the R&D program and, therefore, would not necessitate a 3 year program delay.

2.2. Main Recovery Subsystem

2.2.1. Descent Velocity

The nature of container airdrop makes the descent velocity issue a complex one. Specifically, the wide range of container weights (500 to 2,200 pounds) with a single fixed size parachute will produce a wide range of descent rates. The current CDS has two modes,

high velocity (HV) and low velocity (LV). For LV, a G-12 main recovery parachute is used, which yields a descent velocity range of between 14 and 27 feet per second (fps). For HV, either a 26 foot ringslot main recovery parachute is used, which descends between 41 and 76 fps, or a 22 foot ringslot main recovery parachute is used, which descends between 48 and 90 fps. Thus, a CDS container may impact the ground like a "feather" (14 fps) or like a "ton of bricks" (90 fps): one rate more than **6** times faster than the other. The TOD suggested eliminating the dual mode CDS concept in favor of a single descent velocity system. If there was only one system, there could be substantial savings in contingency stocks, since the current system calls for **both** HV and LV containers to be prerigged in the depots.

The descent velocity issue was studied in depth in the TOD. A single descent velocity in the range of 30 to 50 fps was recommended based on life cycle costs, wind drift considerations, and the high-speed performance of the main recovery subsystem that would provide such a descent velocity.

2.2.2. Single Canopy - No Reefing

The TOD suggests a 45 foot diameter flat circular solid construction parachute as the main recovery subsystem for HSCDS. The design includes heavier duty materials than the G-12, and incorporates the heaviest canopy material near the apex. A new pilot parachute must be identified or developed to aid the deployment of this new chute in the high-speed environment. This canopy could be used for the entire range of container weights. The descent velocity would range from 18 to 38 fps, which is outside the recommended descent velocity range for light weight containers. The performance of this parachute at 130-150 and 250 KIAS was analyzed in the TOD. The computer simulation results are summarized in Table 2.1.

Table 2.1. Performance of 45 foot diameter Solid Canopy

Altitude Loss to First Vertical (feet) 130 KIAS	Altitude Loss to First Vertical (feet) 250 KIAS	Maximum Backswing Angle (degrees) 2,200 pounds & 250 KIAS	Theoretical Maximum Opening Forces (pounds)
244	154	6	26,260

2.2.3. Single Canopy - Variable Reefing

The same canopy as described in section 2.2.2 is suggested in this concept with one alteration. The canopy would be unreefed for heavy weight ranges (e.g., 1,301 to 2,200 pounds), reefed with a medium length reefing line for medium weights (e.g., 826 to 1,300 pounds), and reefed with a shorter reefing line for light weights (e.g., 500 to 825 pounds). The parachute would have two reefing lines of different size rigged each time it is packed,

with the reefing lines coded by color or otherwise clearly identified. When attaching a parachute to a container, a chart in the rigging manual would identify to the rigger which lines to cut. Either all of the lines will be cut or one specific line will not be cut. A hardware link could be used to connect or disconnect the proper lines, or an expendable webbing or cordage tie could connect the ends of the reefing line to allow the reefing lines to be reuseable.

2.2.4. Clusters of Smaller Parachutes

Utilize one specific type and size parachute for all drops. As the payload increases additional chutes will be rigged on the load, thereby creating clusters of small main canopies for heavier containers (e.g., 500 to 1000 pound loads have one chute, 1000 to 1500 have two chutes, and 1500 to 2200 pound loads have three chutes). There are two potential approaches to the clustered concept. The first is to design a new 25 foot diameter, heavy duty solid parachute to be used in clusters. The other is to use the off-the-shelf 28 foot heavy duty ringslot parachute in clusters. The 28 foot ringslot is now used extensively as an extraction parachute for Low Velocity Airdrop (LVAD). It is also currently used to recover 500 pound HSLLADS bundles at 250 KIAS; however, the ability to drop heavier loads at high-speed with a 28 foot ringslot are uncertain. The 25 foot solid would cost substantially less than the 28 foot ringslot. The performance of the cluster at 250 KIAS is uncertain, especially the amount of altitude loss to first vertical.

2.3. Extraction/Ejection Subsystem

2.3.1. Simultaneous Parachute Extraction Method

All of the containers to be dropped per pass will be extracted with one extraction parachute (or a cluster of parachutes). The extraction parachute(s) is deployed and initially acts on all the containers in the stick at once to accelerate them to a prescribed velocity. At this time the extraction parachute would be released from the containers, and the containers would travel under their own momentum off the ramp of the aircraft (there will be some reduction in exit velocity due to friction on the rollers and the rail system). If the extraction velocity is not large enough and the extraction force is cut away early, friction becomes a major problem. However, if the extraction velocity is large (e.g., 80 fps) and the extraction force is cut away later, the contribution of friction is relatively small. The containers that exit the ramp prior to the release of the extraction line would have their static lines deployed directly off the extraction sling. The remaining containers would deploy static lines off the anchor line cable. This approach can be tailored to provide a multiple drop zone capability.

2.3.2. Gravity Extraction with Pull-Up Maneuver

The pull-up maneuver is different from the level flight gravity extraction in that the aircraft will physically nose up its flight path in lieu of, or in addition to, obtaining a positive deck angle in level flight. This method is not currently used since the required deck angles

can be achieved at the lower airspeeds. A pull-up of over 10 degrees will be required to reduce the required DZ length to within the current systems length requirements. This will cause the aircraft to gain in the vicinity of 300 to 500 feet of altitude for sticks of 16 and 40 containers, respectively. The CDS Accuracy Enhancement Study done in 1987, demonstrated during pull-up maneuver gravity extraction that "pilots could not consistently perform the (pull-up) maneuver and call the release. This procedure resulted in the widest variance of exit time and airdrop dispersion."

3.0. BEST TECHNICAL APPROACH

3.1. Container Subsystem

The container subsystem has to be able to meet the restraint requirements in the aircraft, extraction force requirements, parachute opening shock requirements, and the landing force requirements. The existing A-22 cargo bag may be able to meet the restraint and landing requirements, but it can not meet the extraction force and opening shock requirements without substantial modifications. The modifications to the A-22 will add complexity to the rigging and derigging of the containers, which are two of the most important Performance Variables identified in the TOA. Therefore, a new start approach or a new start that maximizes the use of existing materials is the recommended approach for the container.

Both a rigid and a cargo net container have legitimate advantages and disadvantages. However, before one type can be chosen over the other, it is recommended that breadboard prototypes of both the rigid and improved cargo net type containers be designed, constructed and tested. The cargo net design has significant advantages over the rigid concept in terms of container weight, storability, maintenance and unit cost. Therefore, if the cargo net container fares well during the technical demonstration, especially in the areas of in-flight restraint and load shift during parachute extraction, the improved cargo net type will be recommended for inclusion in the Engineering and Manufacturing Development program.

3.2. Main Recovery Subsystem

There are no single main cargo parachutes in the inventory that can meet the 250 KIAS airspeed and the 300 foot drop altitude requirements.

3.2.1. Descent Velocity

Recommend a single mode, intermediate descent velocity system be developed for HSCDS. Also, it is technically best to design the system with a more consistent descent rate than the current system. It is recommended that the descent rate be constrained to a narrower range (e.g., between 30 and 40 fps for all container weights). This approach will assist in reducing the number of honeycomb rigging packages, and will minimize container collisions

during mass container drops, while maintaining a relatively high rate of fall to aid accuracy if the system must be dropped from between 500 and 3,000 feet AGL (e.g., Team Spirit exercises).

3.2.2. Single Canopy - Variable Reefing

The best technical approach for the main recovery subsystem is to develop a 45 foot diameter flat circular solid construction parachute. Further, recommend that the variable reefing concept be incorporated, to maintain a more consistent descent rate.

3.2.3. Clusters of Smaller Parachutes

Although the use of clustered parachutes is not recommended as "best," it has several attractive potential benefits. The cost for a 25 foot solid parachute would be close to one-third that of the proposed 45 foot solid, and less than three chutes would be needed for lighter weight containers. However, any savings here could be dramatically reduced if the majority of containers dropped were heavier than 1,500 pounds -- which is perceived by the materiel developer to be true. Since the "low and fast" performance of clusters with CDS is uncertain, it is recommended that clusters of 28 foot ringslots be tested during the technical demonstration. Development of a 25 foot solid should not be pursued until the performance of the ringslot clusters is assessed. It is recommended that the combat developer and materiel developer agree to the best technical approach for the main recovery subsystem after the technical demonstration..

3.3. Extraction/Ejection Subsystem

The stored energy and electromechanical ejection methods that were studied, either will not adequately fulfill the requirements, require unacceptable modifications to the aircraft, require an excessive amount of power, are too large to fit within the confines of the cargo compartment, and/or will be too expensive. The current method of extraction (level flight gravity) cannot be achieved at the higher airspeeds. Of the four alternatives explored for load extraction, the aerodynamic (parachute) method has the most potential for success. Certain aspects of parachute extraction of containers have already been demonstrated in testing [1].

3.3.1. Simultaneous Parachute Extraction

The best technical approach for extracting containers from aircraft is simultaneous parachute extraction. This type of extraction subsystem will consist of a drogue/tow parachute, extraction parachute(s), and an extraction bridle/pusher assembly. It is recommended that the tow plate assembly be used for all airdrops at high-speed. These drops can only be conducted from the MC-130 or the C-17, both of which have a tow plate assembly as standard equipment. For low speed drops, the tow plate could be used for those aircraft that have the tow plate; however, low speed drops from C-141 and C-130 aircraft without tow plates could deploy extraction parachutes directly from the bomb rack. Recommend two new parachutes be developed for high-speed extractions. These chutes will be heavy duty ringslots

(5 and 15 foot diameters), constructed of materials even sturdier than the existing ringslot extraction parachutes. Also, development of a bridle/pusher assembly should continue.

3.4. Number of Systems

3.4.1. Single High/Low Speed System

The best technical approach is to develop a single high/low speed system. The proposed main recovery parachute should be able to meet the requirements for 250 KIAS, 300 feet, while still maintaining the capability to deliver at 130-150 KIAS and 300 feet. The cost of the proposed parachutes will be significantly less than the G-12, and the new parachutes will survive more airdrops than the G-12. The new container will not present any technical problems if employed at 130-150 KIAS. Standardization to one type of container for all airspeeds is the most logical approach from a logistics and cost standpoint. Although gravity extraction of the new containers with the new main parachute can be accomplished, it is recommended that simultaneous parachute extraction be used at the low speeds as well. Existing ringslot extraction parachutes will be used at the low airspeeds in lieu of the developmental high-speed extraction chutes. Two primary reasons for recommending this are dramatically improved point of impact accuracy and reduced dispersion (leading to smaller drop zone requirements than gravity extraction). Since the extraction bridle/pusher assemblies will be developed for high-speed, they will be available for low speed use. The associated cost of using this extraction subsystem is very low on a cost per container dropped basis. Finally, if the system is rigged in the aircraft the same way for any airspeed, a mission change can be facilitated in flight by simply changing over the extraction parachutes on the floor or in the bomb rack. If there is a potential need to change the drop speed during the mission, both types of extraction parachutes can be carried on the aircraft to allow such a delivery speed change.

4.0. COST DATA

Several assumptions were made within this cost data presentation. For example, it was estimated that 8,000 containers per year are dropped in training. On the basis of discussions with ATCOM (Prov), it was estimated that the current total quantity of CDS (both HV and LV) required for War Reserves and Contingency Stocks is 56,000. Since there will only be one HSCDS "mode," it was postulated that 45,000 new container systems in depot stocks would be adequate to maintain the same level of readiness.

R&D costs include the funds already spent beginning in FY90.

4.1. Container Subsystem

4.1.1. R&D, Production and Fielding Costs

Table 4.1. R&D, Production and Fielding Costs for Container Subsystem

	Total R&D Costs ($Th)	Estimated Unit Cost ($)	Estimated Annual Production Quantities *	Estimated Annual Production Costs ($Th)	Total Fielding Costs ($Th) **
A-22	0	$240	1,000	$240	$74.4
Plywood Skid	0	$22	8,000	$176	$54.6
Cargo Net	$1,000	$400	600	$240	$74.4
Rigid	$1,000	$1,200	500	$600	$186.0
Aluminum Skid	$350	$275	600	$165	$51.2
Composite Skid	$350	$180	1,000	$180	$55.8

* These are annual production estimates of containers/skids required to support training. These numbers do not address the production quantities required to meet War Reserves and Mobility Stocks.

** Includes packaging, transportation, and technical manuals (estimated by ATCOM's 31 percent fee)

4.1.2. Facilities and Sustainment Costs

Table 4.2. Facilities and Sustainment Costs for Container Subsystem

	Costs for New Facilities Required (for Production, Storage and Training)	Annual Replenishment Spares ($Th)	Annual Depot Maintenance ($Th) **
A-22	0	$25	0
Plywood Skid	0	0	0
Cargo Net	0	$40	0
Rigid	0*	$100	$100
Aluminum Skid	0*	0	$20
Composite Skid	0	0	$10

* Could actually show a savings here, since current facilities may not be required to store these items if they are stored outside.

** These costs are actually Intermediate (not Depot) Level repairs. This does not include unit maintenance.

4.2. Main Recovery Subsystem

4.2.1. R&D, Production and Fielding Costs

Table 4.3. R&D, Production and Fielding Costs for Recovery Subsystem

	Total R&D Costs ($Th)	Estimated Unit Cost ($)	Estimated Annual Production Quantities *	Estimated Annual Production Costs ($Th)	Total Fielding Costs ($Th) **
26 Foot High Velocity Ringslot	0	$280	500	$140.0	$43.4
G-12E Solid Canopy	0	$1,750	1,000	$1,750.0	$542.5
Single Canopy -No Reefing	$1,350	$990	500	$495.0	$153.5
Single Canopy - Variable Reefing	$1,350	$1,070	500	$535.0	$165.9
Clusters of 28 foot Ringslots	$1,100	$725	1,300	$942.5	$292.2
Clusters of 25 foot Solids	$1,350	$360	1,300	$468.0	$145.1

* These are annual production estimates of parachutes required to support CDS training only. These numbers do not address the production quantities required to meet War Reserves and Mobility Stocks.

** Includes packaging, transportation, and technical manuals (estimated by ATCOM's 31 percent fee)

4.2.2. Facilities and Sustainment Costs

Table 4.4. Facilities and Sustainment Costs for Recovery Subsystem

	Costs for New Facilities Required (for Production, Storage and Training)	Annual Replenishment Spares ($Th)	Annual Depot Maintenance ($Th) *
26 Foot High Velocity Ringslot	0	$48	$20
G-12E Solid Canopy	0	$100	$60
Single Canopy -No Reefing	0	$12	$10
Single Canopy - Variable Reefing	0	$25	$15
Clusters of 28 foot Ringslots	0	$120	$100
Clusters of 25 foot Solids	0	$45	$40

* These costs are actually Intermediate (not Depot) Level repairs of the parachutes. This does not include unit maintenance.

4.3. Extraction Subsystem

4.3.1. R&D, Production and Fielding Costs

This assumes that 50 percent of the drops are conducted at 130-150 KIAS and 50 percent at 250 KIAS. In addition, it is assumed that 67 percent of the drops are from C-130 or MC-130 and 33 percent of the drops are from C-17 or C-141. It was assumed that an extraction line can be reused 20 times, and that the average number of containers per drop is eight. Thus, the total drop zone passes per year is 1,000. Also, it was assumed that four pusher assemblies will be procured for each of 650 aircraft that will be airdrop qualified.

Table 4.5. R&D, Production and Fielding Costs for Extraction Subsystem

	Total R&D Costs ($Th)	Estimated Unit Cost ($)	Estimated Annual Production Quantities *	Estimated Annual Production Costs ($Th)	Total Fielding Costs ($Th) **
Standard 15 Foot Extraction Parachute	$60	$190	15	$2.9	$0.9
Standard 22 Foot Extraction Parachute	$60	$560	10	$5.6	$1.7
Standard 28 Foot Extraction Parachute	$60	$950	10	$9.5	$2.9
Extraction Line, 60 Foot, 3 Loop	0	$103	34	$3.5	$1.1
Extraction Line, 140 Foot, 3 Loop	0	$230	17	$3.9	$1.2
High-Speed 5 Foot Ringslot Chute	$390	$70	25	$1.8	$0.5
High-Speed 15 Foot Ringslot Parachute	$390	$260	15	$3.9	$1.2
Extraction Pusher Assembly	$390	$500	65	$32.5	$10.1
Gravity Extraction with Pull-Up Maneuver	$400	N/A	N/A	N/A	N/A

* These are annual production estimates of parachutes and lines required to support CDS training only. Quantities of standard extraction parachutes are for low speed drops, while quantities of high-speed chutes are for 250 KIAS drops.

** Includes packaging, transportation, and technical manuals (estimated by ATCOM's 31 percent fee)

4.3.2. Facilities and Sustainment Costs

Table 4.6. Facilities and Sustainment Costs for Extraction Subsystem

	Costs for New Facilities Required (for Production, Storage and Training)	Annual Replenishment Spares ($Th)	Annual Depot Maintenance ($Th) *
Standard 15 Foot Extraction Parachute	0	$0.6	$1.8
Standard 22 Foot Extraction Parachute	0	$0.5	$1.5
Standard 28 Foot Extraction Parachute	0	$0.5	$1.5
Extraction Line, 60 Foot, 3 Loop	0	0	0
Extraction Line, 140 Foot, 3 Loop	0	0	0
High-Speed 5 Foot Ringslot Chute	0	$0.3	$0.6
High-Speed 15 Foot Ringslot Parachute	0	$0.5	$1.0
Extraction Pusher Assembly	0	$3.5	$5.0
Gravity Extraction with Pull-Up Maneuver	0	N/A	N/A

* These costs are actually Intermediate (not Depot) Level repairs of the parachutes, lines and pusher assembly. Costs do not include unit maintenance.

4.4. Total System Life Cycle Costs

Table 4.7. Total System Life Cycle Costs

Descriptions	Total Quantities for "Full" Fielding *	Total System Unit Cost ($)**	Annual Costs for Training ($M) ***	Total 16 Year Life Cycle Costs ($M) ****
Current System with G-12E	40,000	$2,636	$2.67	$148.2
Current System with 26 Ft HV Ringslot	20,000	$542	$0.37	$16.7
Improved Cargo Net & Skid, 45 Ft Chute-Variable Reefing	49,000	$2,177	$1.41	$129.3
Rigid & Skid, 45 Ft Chute- Variable Reefing	49,000	$3,226	$1.80	$186.9
Improved Cargo Net & Skid, 45 Ft Chute - No Reefing	49,000	$2,073	$1.09	$119.0
Rigid & Skid, 45 Ft Chute- No Reefing	49,000	$3,121	$1.73	$180.6
Improved Cargo Net & Skid, Cluster of 25 Foot Solids	49,000	$1,955	$0.99	$111.6
Rigid & Skid, Cluster of 25 Foot Solids	49,000	$3,003	$1.63	$173.3
Improved Cargo Net & Skid, Cluster of 28 Foot Ringslots	49,000	$3,150	$1.82	$183.5
Rigid & Skid, Cluster of 28 Foot Ringslots	49,000	$4,198	$2.45	$244.9

* Includes War Stocks. Quantities are for containers and main parachutes. It is estimated that 3,000 extraction subsystems (including 2,600 pusher assemblies) are required for "full" fielding.

** System is defined as one container, one main parachute, and a percentage of an extraction subsystem. The high and low speed extraction subsystems contribute only $28 and $30, respectively, to the system unit cost. System unit cost here includes 31 percent ATCOM Fee.

*** Includes production, fielding, facilities, and sustainment costs detailed in sections 4.1, 4.2 and 4.3. The extraction subsystem contributes only $59,100 per year in annual costs for training (this assumes an equal distribution of low and high-speed drops, as well as, an equal distribution of extraction parachutes).

**** Does not include R&D costs.

The systems described in Table 4.7 assume that the current systems are gravity extracted and the proposed new systems utilize simultaneous parachute extraction at all airspeeds. The current system total life cycle cost is the total of the G-12E and the 26 foot HV systems. This should be compared to each of the other alternative systems life cycle costs. It was assumed that 2.5 cluster chutes would be required per system, in lieu of 3, since some percentage of the loads will require less than three chutes.

When reviewing the cost data, it must be reemphasized that these are based on estimates and include certain assumptions. Although the cost data can not be construed as hard numbers, there are general cost trends that can be gleaned from them.

Close to 80 percent of current life cycle costs are those associated with maintaining War Stocks. An additional cost for these depot stocks, not considered herein, is the cost to repack all the chutes in the depot every six years. Current estimates are $50,000 per year to repack G-12 and 26 foot ringslot parachutes. The depot repack cost for the 45 foot solid parachute is estimated at $40,000 per year.

The life cycle costs for annual training only contribute to about 20 percent of the overall system life cycle costs. On the basis of this, minimizing the total system unit cost is the most effective manner to control total life cycle costs. Nearly 90 percent of CDS are set aside in depots for operational use, most likely a "one time" use. If requiring the system to be reuseable 12 times will cause a significant increase in the total system unit cost, then it would be preferable to accept a lower reuse capability to maintain a lower unit cost.

The total 16 year life cycle costs (LCC) for the current system is estimated to be $164.9 M. All of the improved cargo net systems (except the clusters of 28 foot ringslots) have total LCC that are actually less than the current system. All of the rigid container systems have greater LCC than the current system. The lowest cost new system appears to be the improved cargo net with clusters of 25 foot solids; however, that system may not meet the performance requirements.

If it can meet the performance requirements, the best technical approach will be the improved cargo net, with the 45 foot solid canopy and variable reefing that utilizes simultaneous parachute extraction at all airspeeds. The costs of the "best" system show a total 16 year LCC savings of $35.6 M over the current system. There is a total training savings of $26.1M or $1.63M per year. The cost to fully stock the depot with the "best technical" system (49,000 systems) will be $9.7 M less than to fully stock the current system (includes 40,000, G-12 and 20,000, 26 ft HV systems). An additional intangible cost savings not incorporated into the data, is the cost of equipment damaged, when dropped with the HV system, since the ground impact is much more severe than the "best" system. If the HSCDS replaces both LV and HV container systems, then, that intangible cost will be substantially reduced.

A primary objective of HSCDS is to improve aircraft survivability during container airdrop missions. This BTA suggests that a new system could be developed to accomplish this

objective, while maintaining a lower LCC than the current container delivery system. If the introduction of HSCDS can save just one aircraft from being lost in combat, then the total LCC savings would increase by the value of that aircraft, not to mention the value of the aircrew's lives. In fact, even if the system were never employed at high-speed, and the system was developed and fielded for low speed use only, it would be cost effective. Since the HSCDS will provide improvements for all airspeeds (e.g., better accuracy, improved rigging/derigging, and upgraded load survivability) continued development of HSCDS should be considered a high priority, regardless of the systems ultimate employment scenario.

5.0. ENVIRONMENTAL AND MANPRINT CONCERNS

5.1. Environmental

There are no environmental issues or concerns associated with the development or fielding of HSCDS.

5.2. MANPRINT

Any significant MANPRINT concerns are identified in the Manpower, Personnel and Training (MPT) Analysis. The results of the MPT Analysis will be incorporated into the Cost and Operational Effectiveness Analysis (COEA).

This document reports research undertaken at the US Army Natick Research, Development and Engineering Center and has been assigned No. NATICK/TR-92/031 in the series of reports approved for publication.

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